White Dwarf Star Encyclopedia Article

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White Dwarf Star

A white dwarf is the remnant of a dead star that originally had a mass comparable to that of the Sun. White dwarfs are one of only four possible end states of stellar life cycles.

A star with the mass of the sun supports itself against the inward force of gravity by converting hydrogen to helium in its core via nuclear fusion. After about ten billion years, the star will exhaust its supply of hydrogen. It will then begin fusing the helium in its core to to carbon and oxygen, and nuclear fusion will end. Without fusion to counteract the force of gravity, the star collapses into an object of enormous density.

The collapse comes to a halt when the electrons in the star's atoms are packed together as tightly as possible. Interestingly, the more massive the white dwarf, the smaller it will become. By the end of collapse, a star like the sun will be a white dwarf no bigger than the Earth. Although the surface of a white dwarf is quite hot--10,000° F or more--it is very faint because it is so small.

Astronomer Subrahmanyan Chandrasekhar applied Albert Einstein's theory of relativity to the special conditions that exist within white dwarf stars. He was able to show that it was possible to calculate the radius of a white dwarf if its mass was known. It turns out that any white dwarf with more than 1.4 times the mass of the sun could not exist as a dwarf: it would be crushed by its own gravity and collapse into a neutron star. This 1.4-solar-mass threshold became known as the Chandrasekhar limit.

When a star becomes a white dwarf by exhausting its nuclear energy sources, and when it collapses and cannot contract any farther, what becomes of it? Electron gas conducts the remaining energy out to the surface of the white dwarf, where it radiates into space in a thin layer. As the white dwarf slowly cools, it ceases to shine and becomes a black dwarf (not to be confused with a black hole). The cold mass of the black dwarf drifts unseen and undetected through space. It takes a very long time for a white dwarf to cool enough to become a black dwarf. Some astronomers suspect the galaxy hasn't aged enough for any to have formed yet. If any have formed, it will not be easy to find them.